From open-access to private property regimes: Strategic Interactions in the Snow Crab fishery

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Introduction - **Snow Crab, *Chionoecetes opilio***

- **Introduction**
  - 1996
  - SouthEast Barents, Goosebank
  - Ballast Water / Range expansion

- **Distribution Area**
  - **Native**: N. Pacific (E. Bering Sea), NW Atlantic, (incl. Canada & Greenland)
  - **Invasive**: N Russian EEZ & Loophole
The Fishery

- Open access (2012 – 2015)
- Sedentary designation (2015)
- Property rights enforcement
  - RU Loophole (Sept. 2016)
  - NO Loophole & SFPZ (Jan 2017)
- Management

![Graph showing estimated catch ('000 tn) SC > 100 mm]

- EU
- Norway
- Russia

Source: Hvingel et. al., 2017

![Graph showing TAC (tn)]

- 1st phase
- 2nd phase
- 2016
- 2017
- 2018
- 2019


Source: Hvingel et. al., 2017
Uncertainties

• Invasion Impacts
  • Potential Negative Impacts
    • Competition with bottom feeding fish & benthic species (10 to 30% reduction in benthic biomass) (Hvingel et. al., 2015 - NoBa-Atlantis)
    • Overlap with Northern shrimp fishery (bycatches & ghost crab pots)
  • Potential Positive Impacts
    • Biomass recycling role - Increase in nutrients available for fish or other predators (cod, haddock, capelin)

• Stock Estimates & Spread
  • 50 - 75,000 tons, 2.5 bil. NOK
  • NorthWest towards Svalbard FPZ
  • Norwegian Catch (2017): 3,061 tn (TAC: 4,000 tn)
• Sedentary or Water Column species?
  • Adheres to the continental shelf & not EEZs
  • 85% of Loophole on Russian continental shelf
  • No requirement for cooperative management
  • 1920 Svalbard Treaty

• Other concerns
  • Continental shelf resources: Oil & gas, minerals
  • Worldwide markets: Increasing prices, declining quotas & stocks (Alaska & Canada)

*Can private property rights solve externality problems when those are coupled with spatial externalities?*

- Fisheries economics literature
  - **Dogma:** Closing the commons enhances profits with private, decentralized or common property management regimes
  - **Concerns:** Shifts in equality & distribution of benefits rather than overall benefits

- Findings
  - Conventional wisdom “**Property rights improve outcomes**” fails
  - Traditional assumptions about property rights in fisheries need refinements that integrate ecological & economic concerns
  - Details of ecological processes matter in determining net benefits
    - Ecological, Economic, Legal, Climatic framework
Should Norway share?

The Game

- Will Norway share profits/volumes via controlled harvest, as they have historically done with other fish stocks in the Loophole & the Svalbard Fisheries Protection Zone?

- They have chosen not to
  - Perception of the SC being a continental shelf resource
  - Being strategic regarding other continental shelf resources it is expected to affect

- 1-period sequential, complete information

- We define the conditions for the subgame perfect equilibria by backwards induction

- Players
  - EU (Player I)
  - Norway (Player II)
Payoffs

✓ Fishing & Enforcement
EU vessel operators
• F: Fishing
• NF: No Fishing
Norway
• E: Enforcement
• NE: No Enforcement

✓ Beliefs & Probabilities
• (θ): Norway will enforce, given that EU decides to partake in the fishery,
• (1-θ): will not enforce, given that EU decides to partake in the fishery
• (p): Court decides in favor of Norway’s enforcement (J)
• (1-p): Court decides against Norway’s enforcement (NJ)
Payoffs & Transaction Costs

**Payoffs**

\[ \pi_{I,F} = \sigma \cdot \pi_T \]  
EU’s payoff when the sharing rule is in place

\[ \pi_{II,F} = (1-\sigma) \cdot \pi_T \]  
Norway’s payoff when the sharing rule is in place

**Stage I - EU vessels choose to join the fishery or stay out of it**

\[ \pi_{II,NF} \]  
Norway’s payoff when the EU decides not to fish \( \pi_T \)

**Stage II - Norway chooses to enforce (or not) property rights on EU vessels**

\[ \pi_{I,F,NE} \]  
EU payoffs when Norway decides not to enforce

\[ \pi_{II,F,NE} \]  
Norway’s payoff when Norway decides not to enforce

**Stage III - The Norwegian court decides whether the enforcement upon EU vessels is fair or not**

\[ \pi_{I,F,J} = L + C_{C,EU} < 0 \]  
EU payoffs when the Norwegian court finds enforcement fair

\[ \pi_{II,F,J} = \pi_T - C_{C,N} - C_E \]  
Norway’s payoffs when the Norwegian court finds enforcement fair

\[ \pi_{I,F,NJ} = \sigma \cdot \pi_T - C_{C,EU} - L \]  
EU payoffs when the Norwegian court finds enforcement unfair

\[ \pi_{II,F,NJ} = (1-\sigma) \cdot \pi_T - C_{C,N} - C_E \]  
Norway’s payoffs when the Norwegian court finds enforcement unfair

\[ \pi_{II,F,NE} > \pi_{II,NF} > 0 \]

**Transaction Costs**

- \( C_E \): Cost of enforcement for Norway (\( C_E > 0 \))
- \( C_{C,EU} \): Court costs for EU vessel operators (\( C_{C,EU} > 0 \))
- \( C_{C,N} \): Court costs for Norway (\( C_{C,N} > 0 \))
- \( L \): Opportunity costs for EU vessel operators when they enter the fishery and lose in court (\( L > 0 \))
Expected Value of Fishing for the EU (Player I)

\[ EV[F] \geq EV[NF] \]

For the EU to decide to partake in the fishery

\[ \theta \left[ p(-L-C_{C,EU}) + (1-p) \left( \sigma \pi_T - C_{C,EU} - L \right) \right] - (1-\theta) \sigma \pi_T > 0 \]

\[ \theta^* < \frac{\sigma \pi_T}{(2-p)\sigma \pi_T - C_{C,EU} - L} \]  \hspace{1cm} (1)

Expected Value of Enforcement for Norway (Player II)

\[ EV[E] \geq EV[NE] \]

For Norway to decide to enforce

\[ p \left( \pi_T - C_{C,N} - C_E \right) + (1-p) \left[ (1-\sigma)\pi_T - C_{C,N} - C_E \right] - (1-\sigma)\pi_T > 0 \]

\[ p^* > \frac{C_{C,N} + C_E}{\sigma \pi_T} \]  \hspace{1cm} (2)
Potential Equilibria

- If EU joins the fishery with a low belief that Norway will enforce, \( \theta < \theta^* \), and Norway enforces with a high probability that the Court will find the enforcement fair, \( p > p^* \), then the equilibrium is \( \{F, E\} \).

- If EU joins the fishery with a high belief that Norway will enforce, \( \theta > \theta^* \), and Norway enforces with a low probability that the Court will find the enforcement fair, \( p < p^* \), then the equilibrium is \( \{NF, E\} \).

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Knowns & Unknowns

• **Sharing rule**
  - 500 tons out of 4,000 tons

• **Fishery Rents** (in landing values)
  - 318 mil. NOK 2016 (for all countries), \( \pi_{II, NF} \)
  - 39.75 mil. NOK 2016 (for EU) under 12.5% sharing rule, \( \pi_{I, F, NE} \)
  - 278.25 mil. NOK 2016 (for Norway) under 12.5% sharing rule, \( \pi_{II, F, NE} \)

• **Enforcement & Opportunity/Idling Costs, \( \pi_{I, F, J}, \pi_{II, F, J}, \pi_{I, F, NJ}, \pi_{II, F, NJ} \)**
  - 6,831 € per vessel/day (19 vessels) or 731,179 € - 1 mil. € each vessel/month,
  - 180,000 € fine for arrested vessel

• ? court expenses for the EU & Norway
• ? Norwegian coast guard enforcement costs
Bio-dynamic strategic decisions
The Game with invasion externalities

• Invasion ecosystem damages expected to lower the payoffs, probably more to Norway (its habitat) than the rest of the world (EU fleet & others)

• If EU vessel operators decide to fish, Norway can accommodate entry by either choosing to:
  ✓ lower their harvest and accommodate EU entry at a profit maximizing harvest level (i.e. Norway gives up profits but overall industry profits are maximized)

  or

  ✓ allow for an increase in total harvest by ignoring the EU fleet’s harvest, which decreases profits but may also decrease damages so that if those are included in the social planner’s objective function, the second choice may be preferred

• A complex interplay between ecology & economic behavior
Foregone Rents to avoid Damages

The Bioeconomic trade-off

$$\max_x NPV = \int_0^\infty e^{-\delta t} ((p - c(x))h - D(x)) \, dt$$

s.t.

$$\dot{x} = g(x) - h,$$

$$g(x) = rx \left(1 - \frac{x}{K}\right)$$
Lessons from the RKC experience

• Norway & Russia have been long managing shared stocks (Joint Russian-Norwegian Fisheries Commission)

• 2007: An agreement to disagree

• Cooperation at the research front only

• Management
  • Russia: Quota, Long-term fishery
  • Norway: Spatially-split management
    • East of 26°E: MSY
    • West of 26°E: Open access
Conclusions & Future Research

• A hard to measure trade-off
  • Complex spatially differentiated stock management
  • Conflicting stakeholders’ interests (economic incentives determine enforcement or not)
  • Conflict between economists’ fishery optimal & ecologists invasion optimal

• Legal complexities
  • Sedentary designation (2015): UNCLOS requirements for extended shelf in Barents
  • Countries involved are parties to the CBD (1992) - COP6 Decision VI/23

• How do the invasion externalities feed into the game?
• Is enforcement hindering the way towards socially optimal management?
• What prevents a cooperative management?
• What is needed for a stable agreement?
• Increased interest in lucrative fishery impeding advances in exploring impacts?
Thank you very much for your attention.

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